MSFC-776

NanoSail-D

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The "NanoSail-D" mission is currently scheduled for launch onboard a Falcon-1 Launch Vehicle in the early June 2008 timeframe. The NanoSail-D spacecraft will consist of a solar sail subsystem stowed in a 2U volume and a 1U spacecraft bus, provided by Ames Research Center. The primary objectives of the NanoSail-D technology demonstration mission are to fabricate, stow and deploy on-orbit a solar sail and perform a de-orbit maneuver to demonstrate a potential orbital debris mitigation technology. The NanoSail-D mission is being developed through a collaborative effort between the NASA Marshall Space Flight Center and the NASA Ames Research Center Small Spacecraft Office.

Details of the NanoSail-D system will be presented, including: 1) design details of the solar sail reflective membrane quadrants, gossamer booms, deployment system and passive attitude control system, 2) design analysis results including structural, thermal, environmental, orbital debris and safety, and 3) test results including deployment, ascent venting, launch vibration and PPOD integration verification.

National Aeronautics and Space Administration

NanoSail-D

CubeSat Developers' Workshop
California Polytechnic State University
San Luis Obispo, CA

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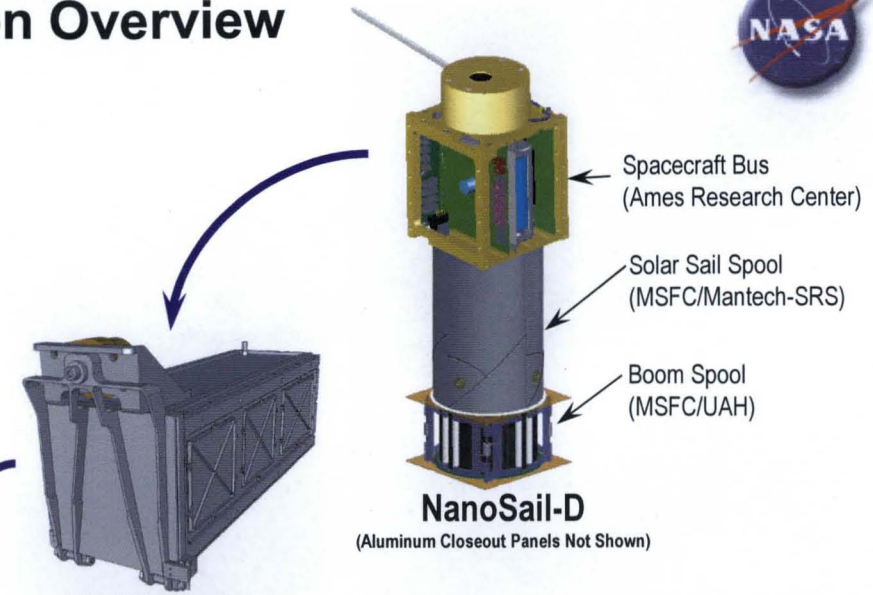
NASA Marshall Space Flight Center

Charles L. Adams
Jacobs/ Gray Research, Inc.

NanoSail-D Mission Overview

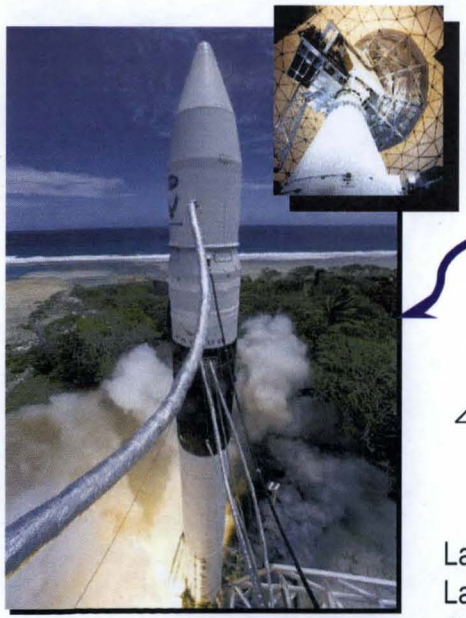
- **Objectives**
  - **Primary**
    - *Establish ARC-MSFC collaborative relationship for small satellite initiatives*
    - *Deploy solar sail leveraging directed work performed by MSFC in prior years under the SMD In-Space Propulsion Program*
  - **Secondary/Opportunity**
    - Demo Orbital Debris Mitigation technology – drag sail
    - Ground Imaging to reduce spacecraft instrumentation
    - Add to flight experience - ARC Bus "light" experience
- **Relevance**
  - Planetary & Heliophysics Science missions
  - Most smallsats orbiting above 450 km struggle to meet <25 year life MOD requirement



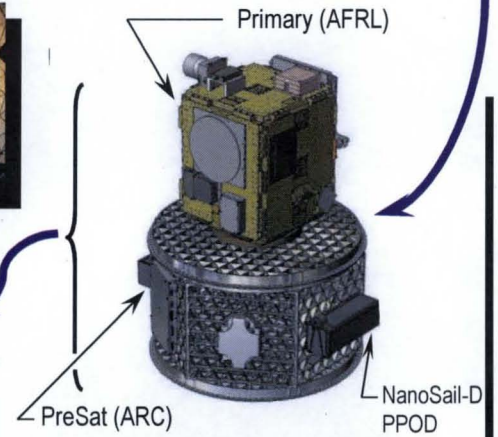
NanoSail-D
(Aluminum Closeout Panels Not Shown)

PPOD Deployer
(Cal-Poly)

Stowed Configuration

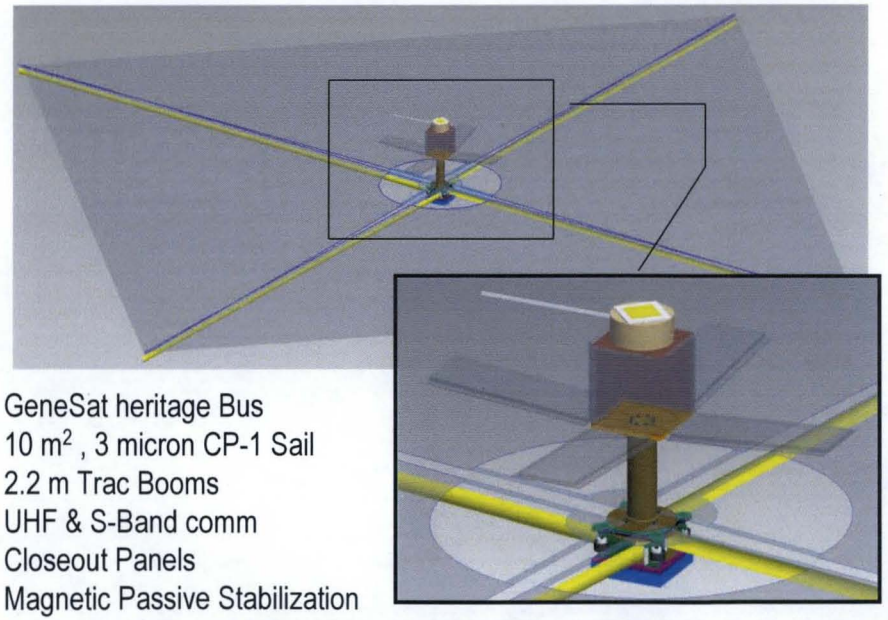


Falcon-1 Third Launch
(SpaceX)



Ride Share Adapter
(Space Access Technology)

Launch Date: June, 2008
Launch site: Omelek Island, RTS (Kwaj)
Orbit: 685 X 330 km, 9º inclination
De-Orbit Period: Approximately 14 days

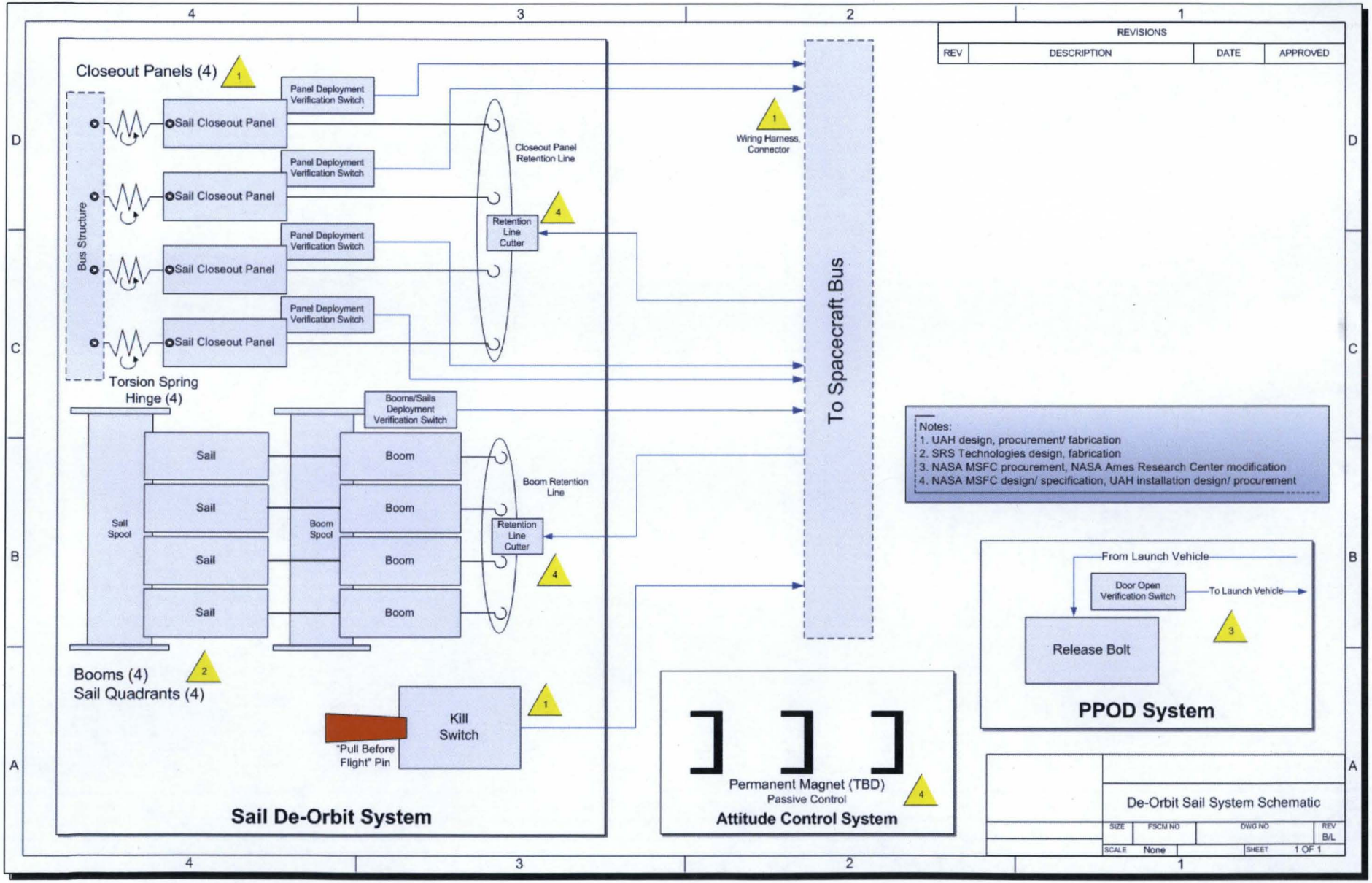


- GeneSat heritage Bus
- 10 m^2 , 3 micron CP-1 Sail
- 2.2 m Trac Booms
- UHF & S-Band comm
- Closeout Panels
- Magnetic Passive Stabilization
- E/PO outreach

Deployed Configuration

NanoSail-D

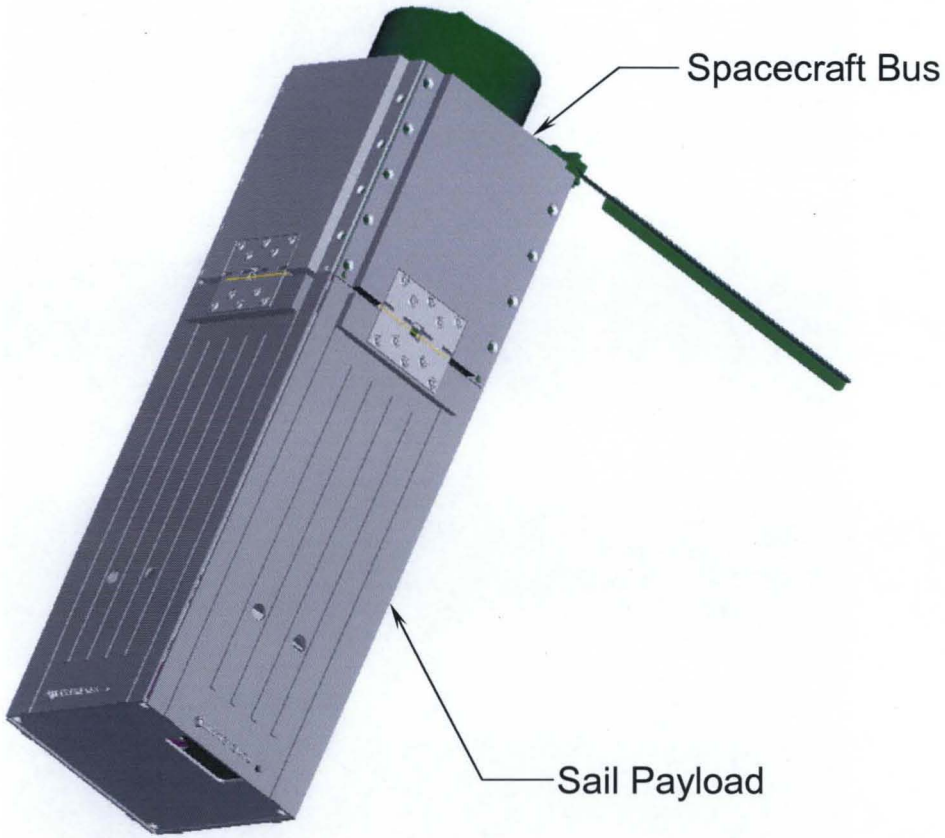
System Schematic



Design Details

- Sail Quadrants
- Booms (Trac and Tape Spring Booms)
- Deployment System (Spools, Governor System Details)
- Bus/Passive ACS

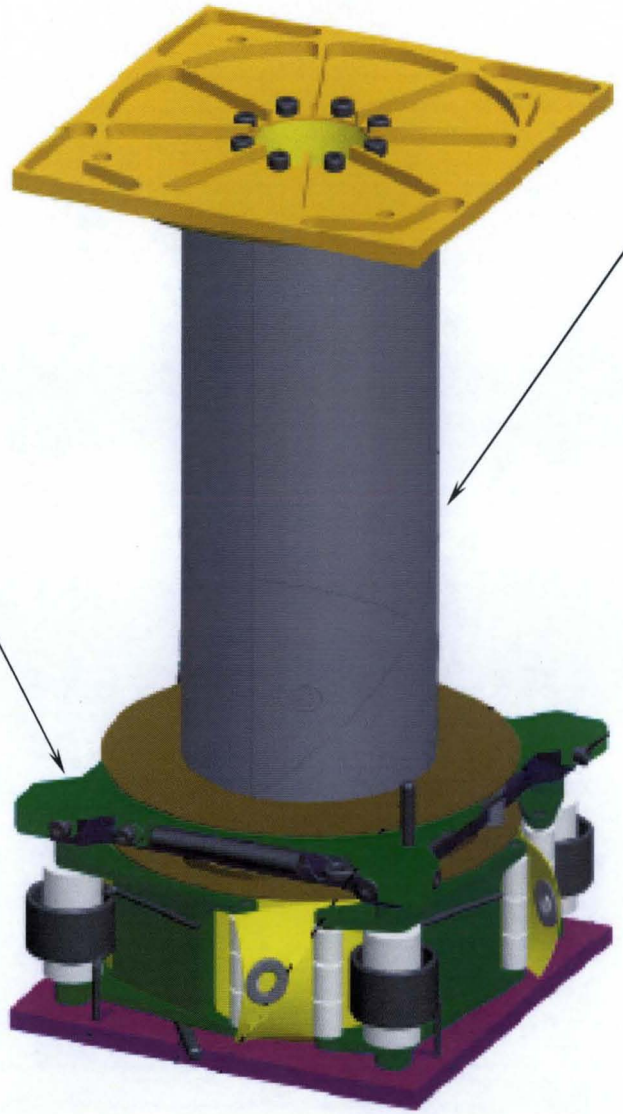
NanoSail-D Payload Subsystem



Stowed Configuration

NanoSail-D

Sail Subsystem Design Details



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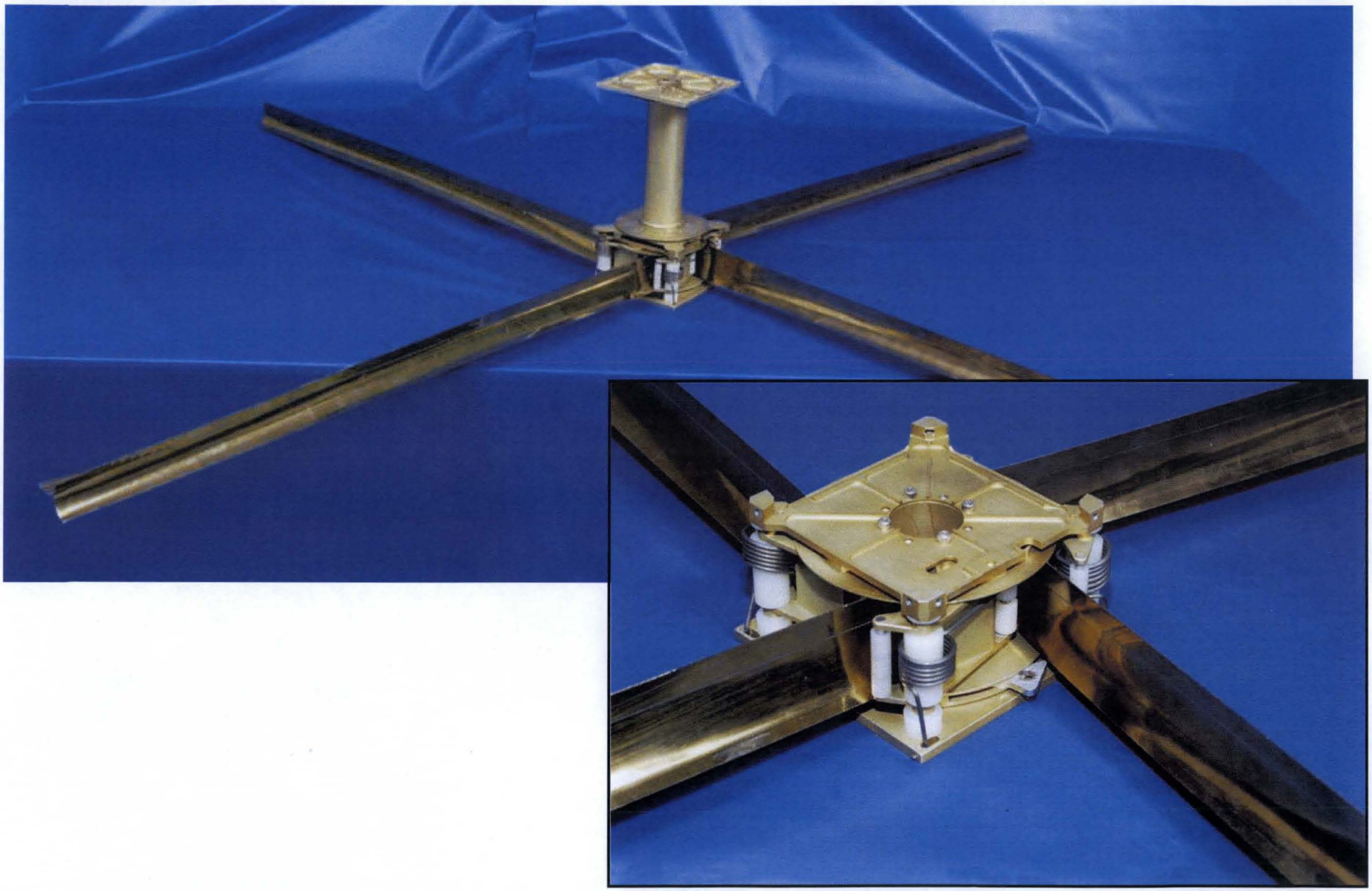
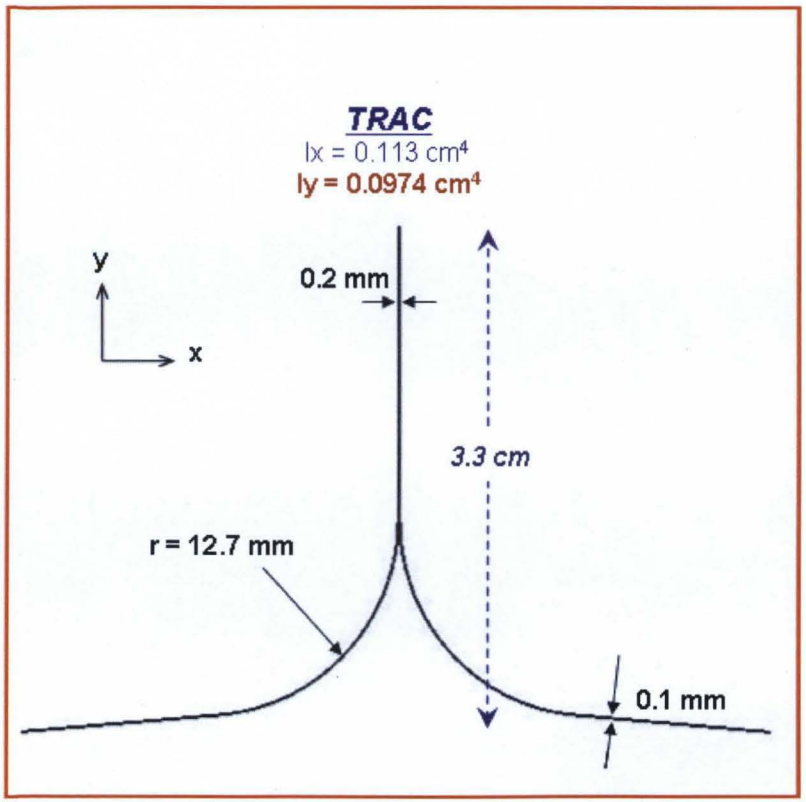
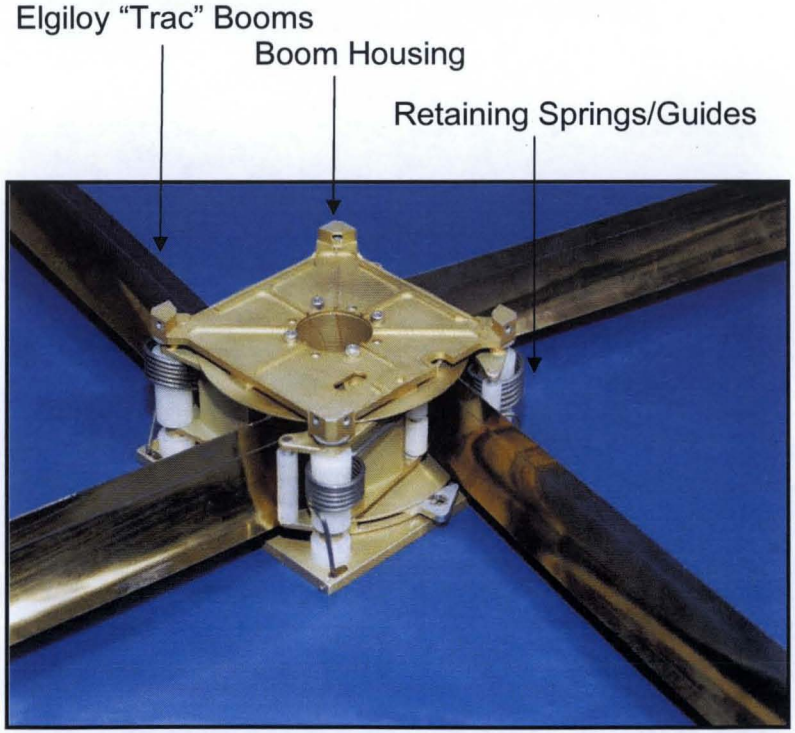
Boom and Deployment Subsystem Details



Boom Subsystem Details





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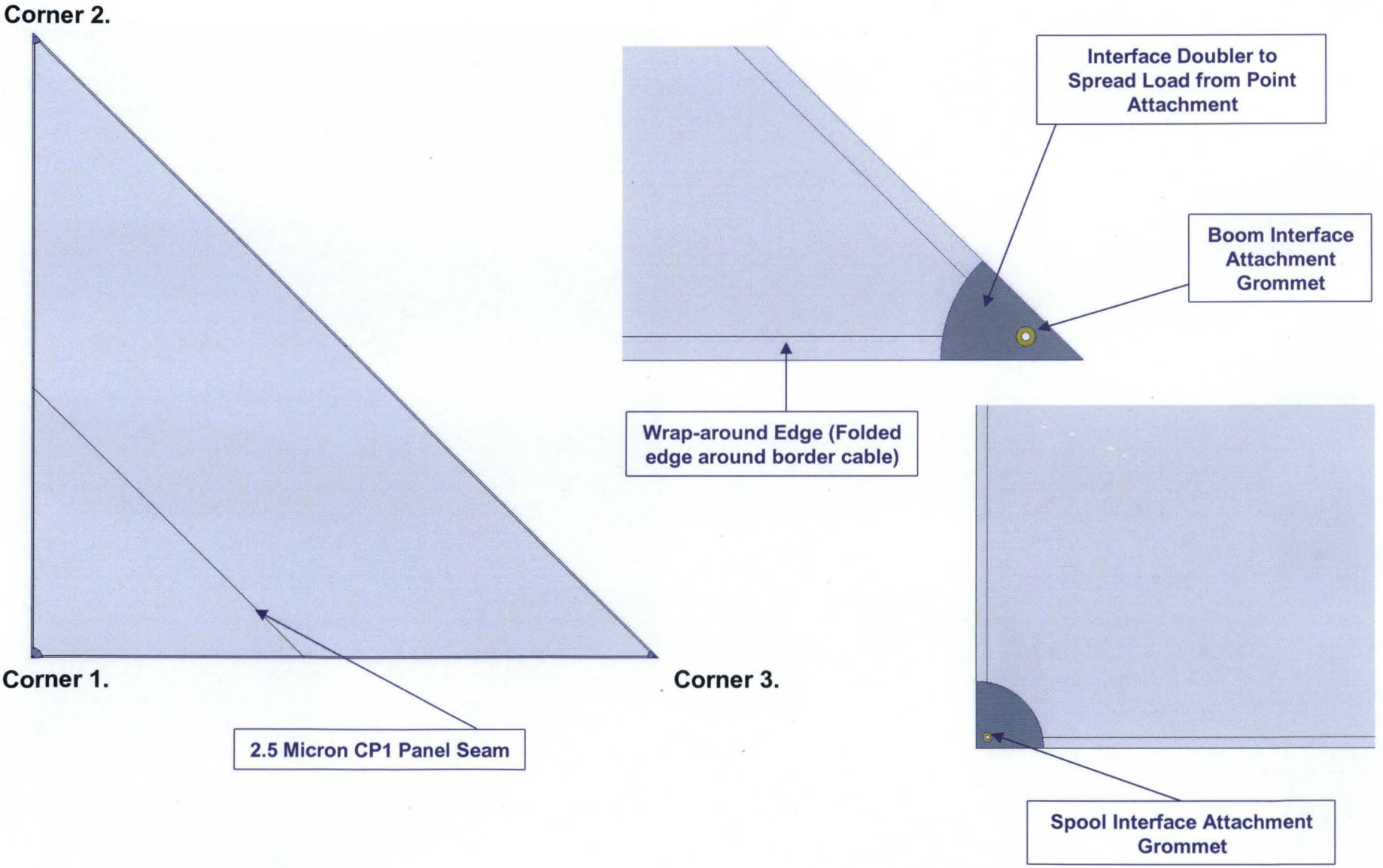
Sail Quadrant Design



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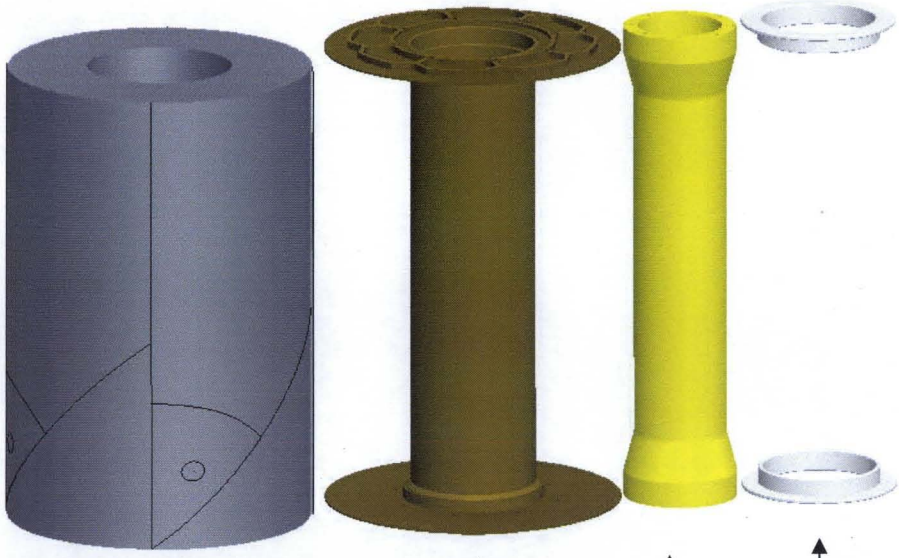
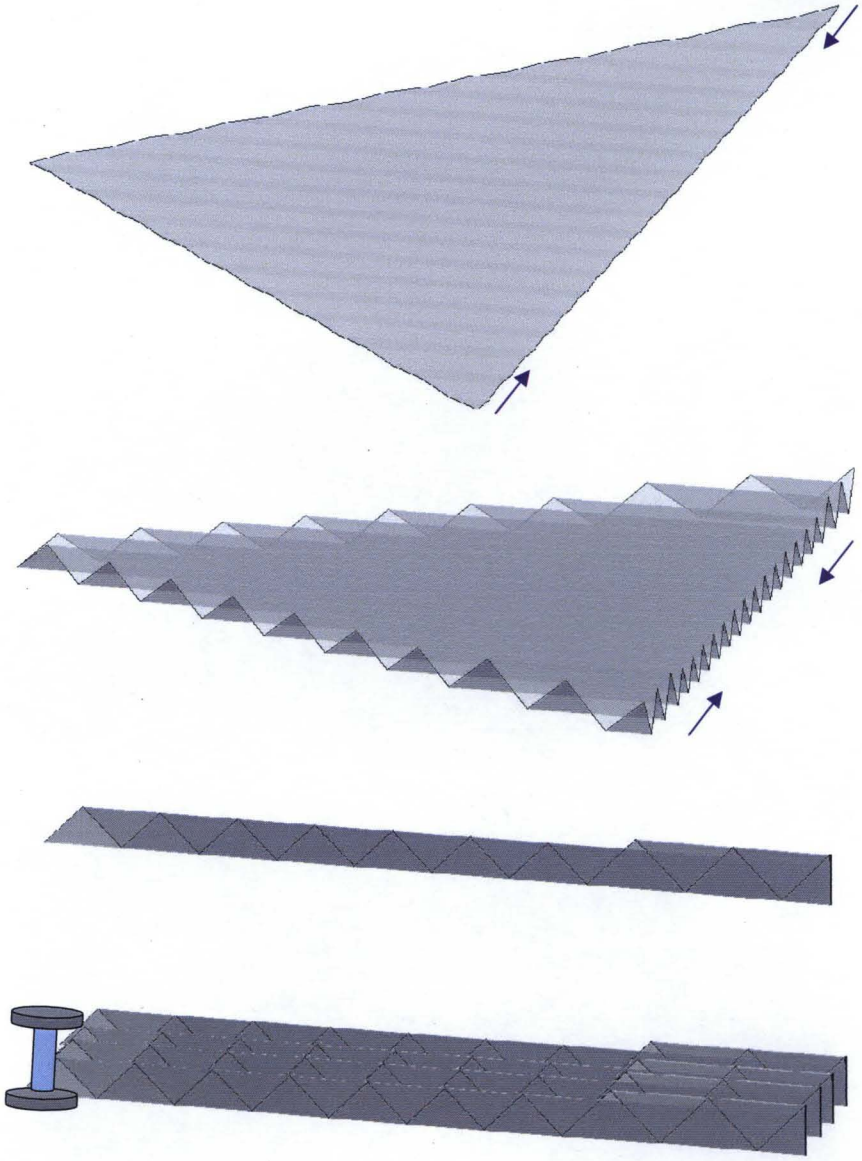
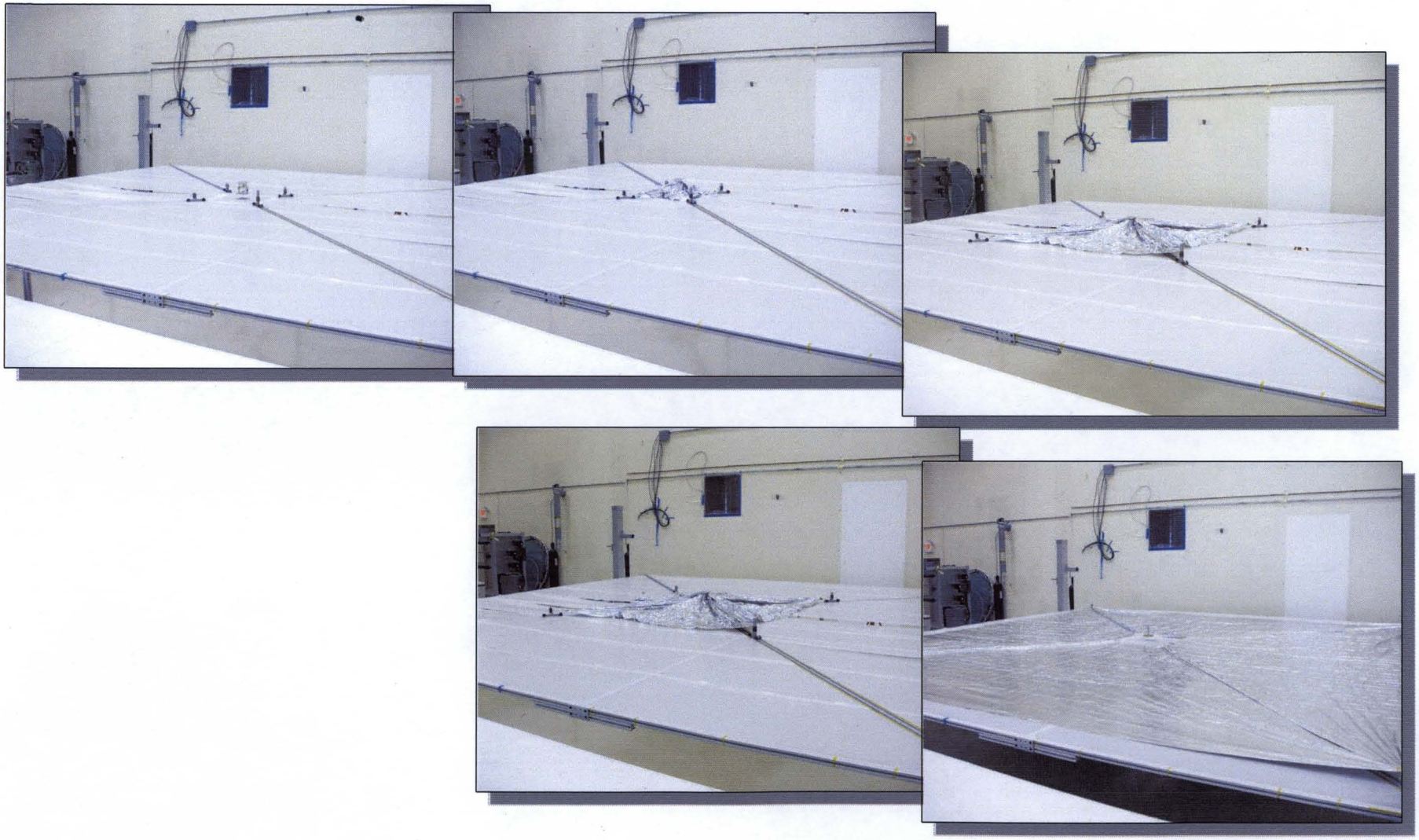
Sail Stowage Configuration





Sail Quadrant Deployment Sequence

4 Quadrant Deployment Demonstration



Analysis Results

- Thermal Analysis
- Structural Analysis
- De-Orbit Predictions, Orbital Debris

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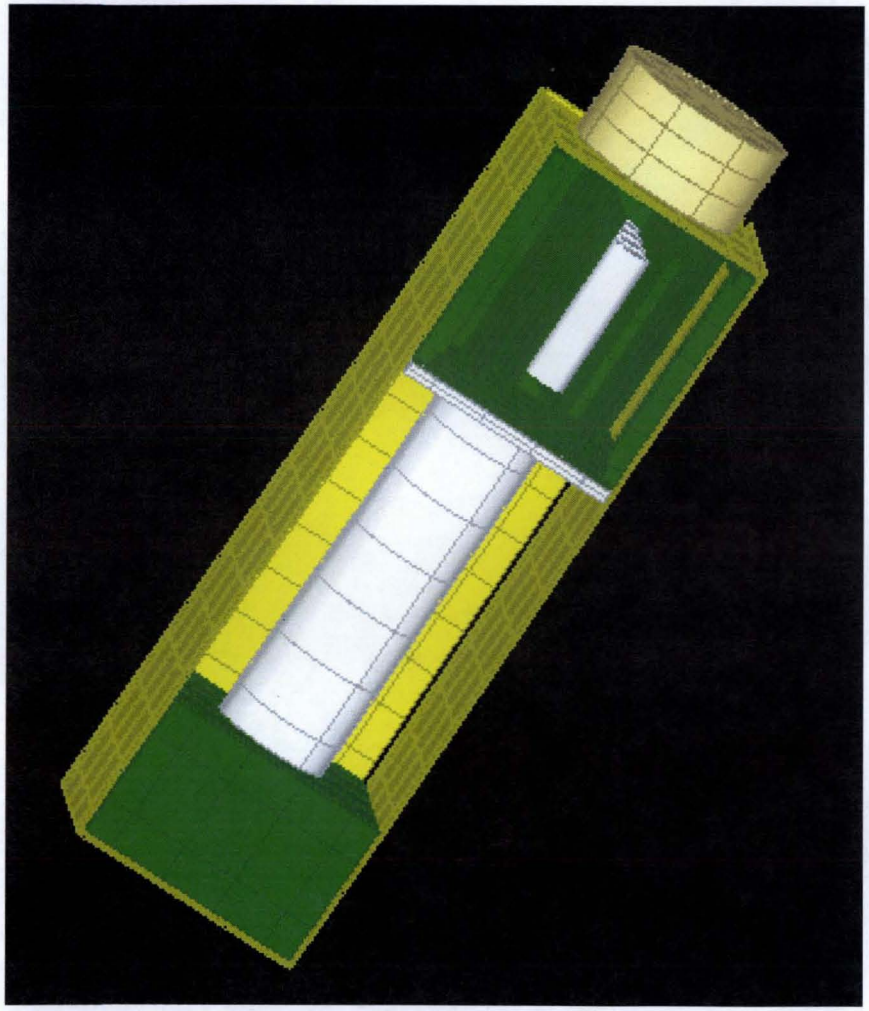
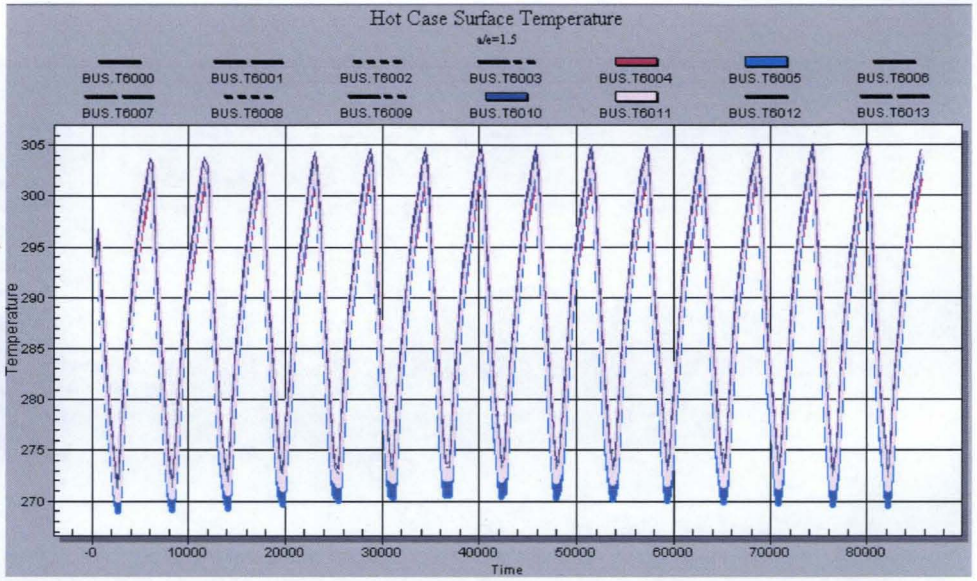
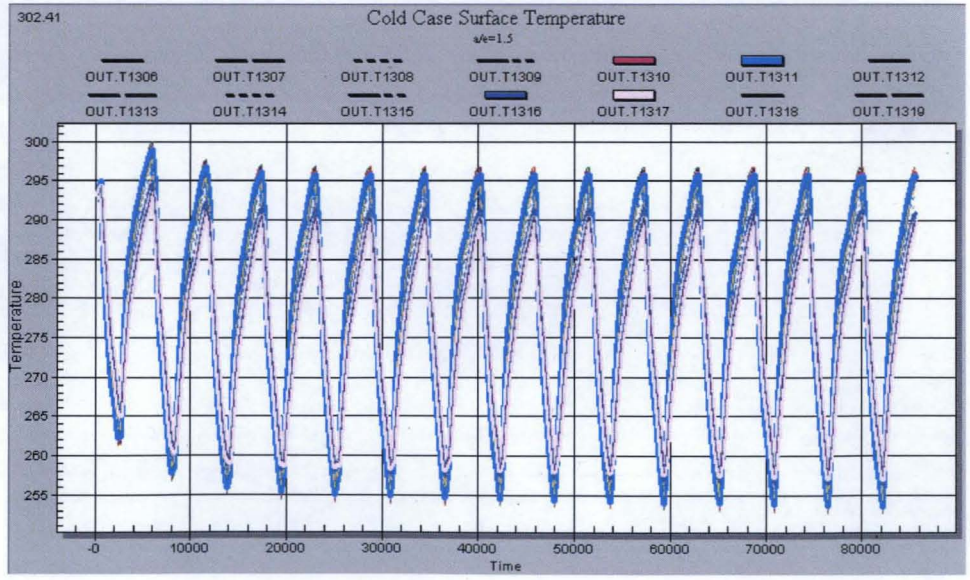
Thermal Analysis Results







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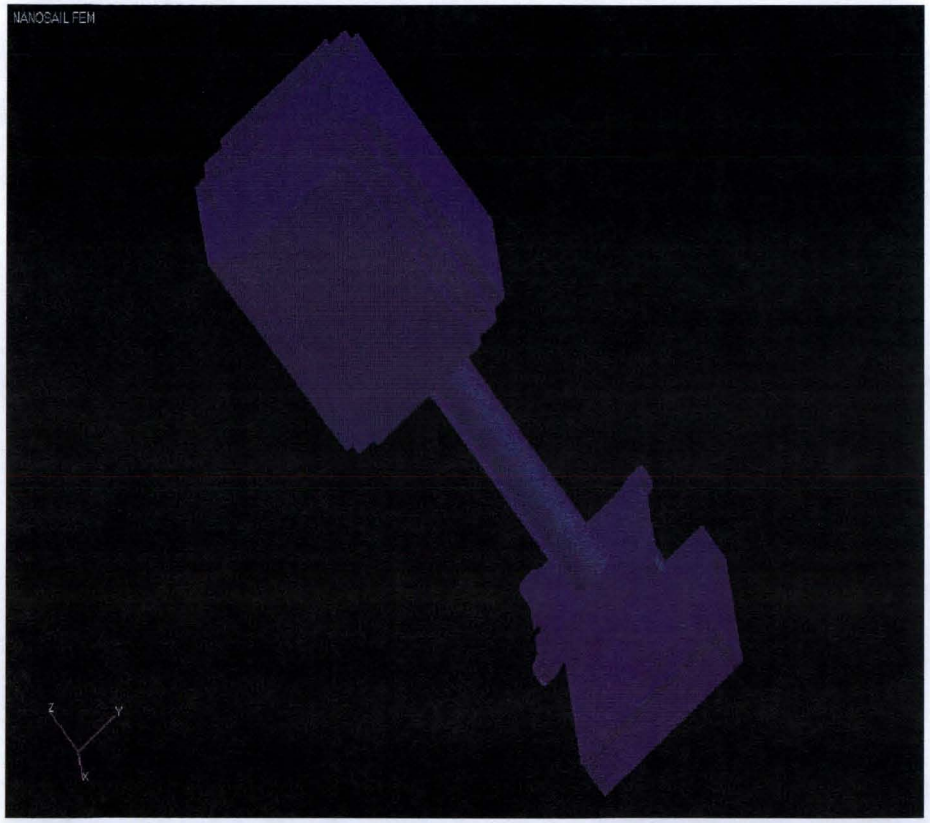
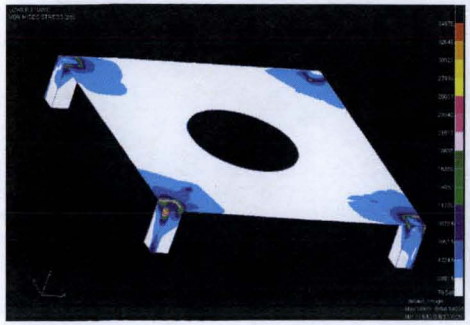
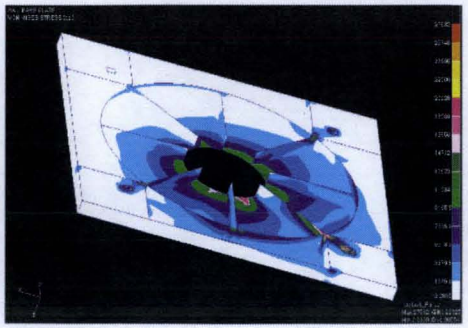
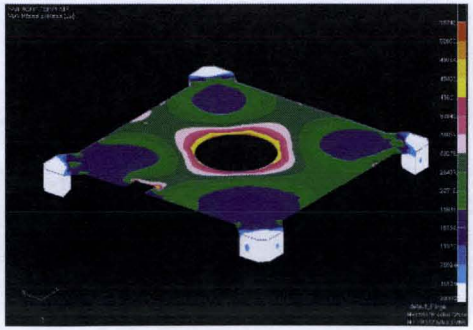
Structural Analysis Results



COMPONENT NAME	NANOSAIL ASSEMBLY MINIMUM MARGIN OF SAFETY SUMMARY TABLE		
	FAILURE MODE	CONDITION	MARGIN OF SAFETY
BOTTOM COVER PLATE	VON MISES	YIELD	+10.506
LOWER FRAME	VON MISES	YIELD	+0.058
SAIL BASEPLATE	VON MISES	YIELD	+0.341
SAIL BOOM TOP PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.086
SAIL BOOM POST	VON MISES	YIELD	+8.519
SAIL BOTTOM PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.019
SAIL POST	VON MISES	YIELD	+15.260
SAIL TOP PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+0.012
BUS INTERFACE PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+10.389
BUS FRAME	VON MISES	YIELD	+1.759
BUS FRAME LOWER PLATE	COMBINED - MAX PRINCIPAL	ULTIMATE	+9.197
BUS FRAME UPPER PLATE	VON MISES	YIELD	+10.075
COVER PLATES	VON MISES	YIELD	>+20.0







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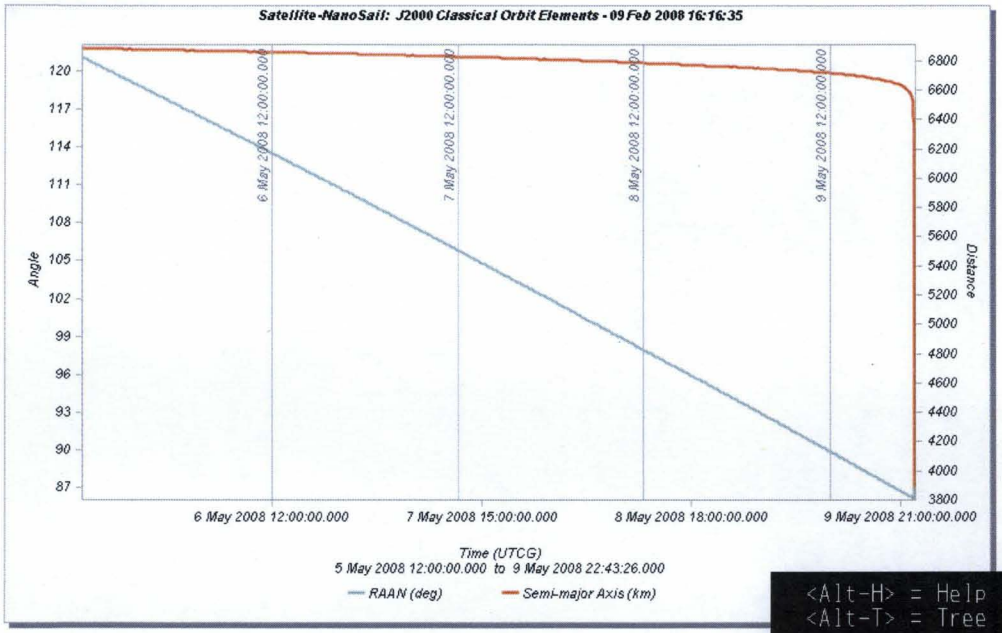
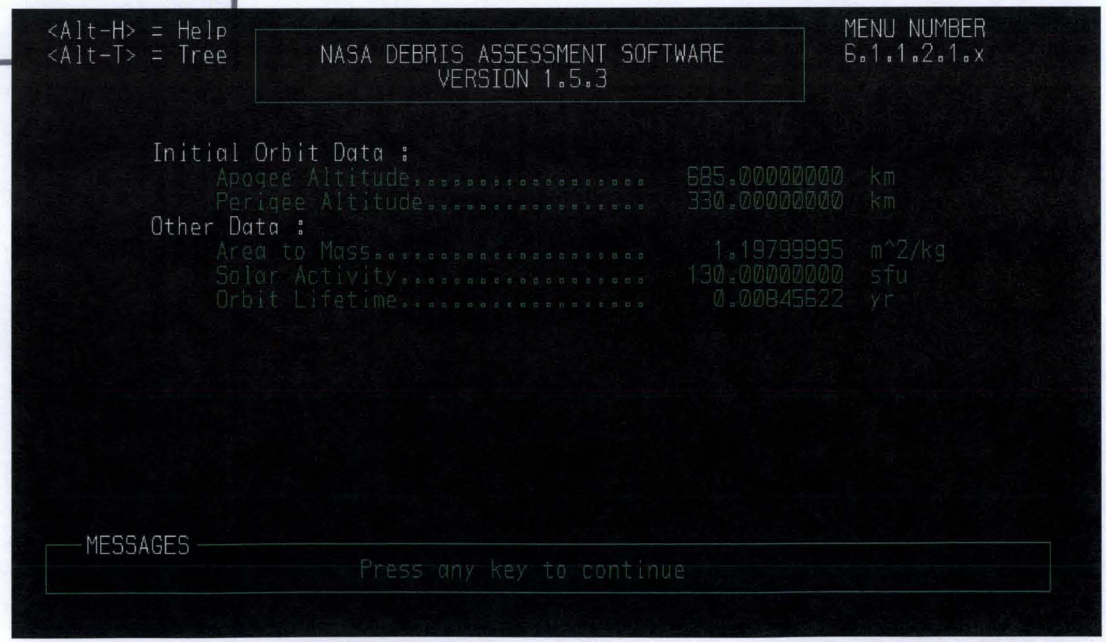
Deorbit Predictions



STK

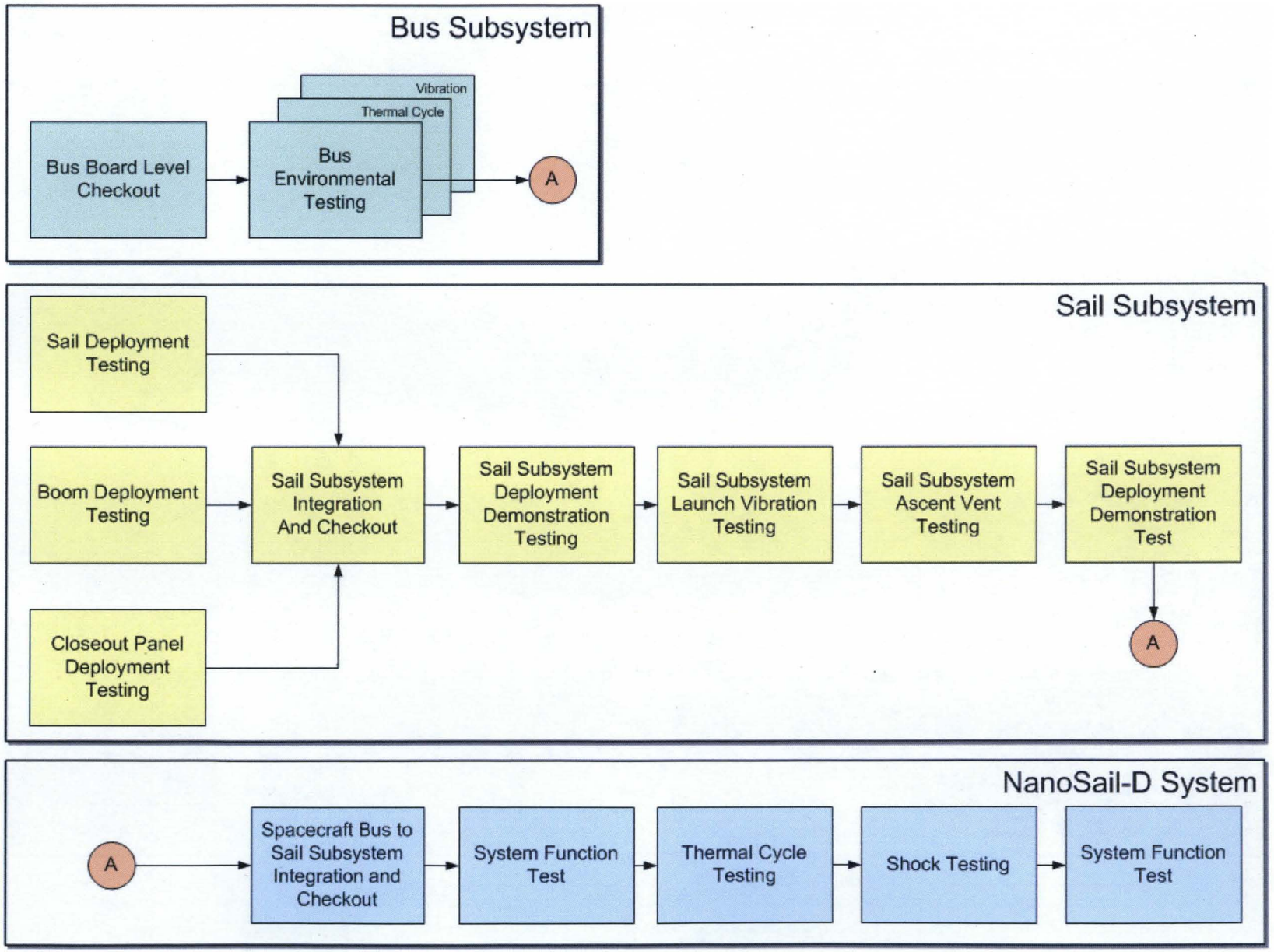


Debris Assessment Software

System Testing

- System Functional Testing
- Deployment Test Results
- Launch Vibration Test Results
- Ascent Vent Test Results
- Testing planned for ARC

Test Sequence



Summary

- NanoSail-D sail subsystem delivered to Ames Research Center on 4/7/08.
- Currently undergoing bus-to-payload integration and testing.
- Integrated system testing through 5/2/08.
- Delivery to launch site on 5/23/08.
- Falcon-1 launch scheduled on 6/10/08.